Great weight, LESS FILLING

ACE Controls' new Magnum Group shock absorber handles far more weight with a package that's no bigger than its predecessor's

Charles J. Murray, Senior Regional Technical Editor

Farmington, MI—Imagine being told to redesign your company's mainstay product, improve its performance by 50%, and constrain its size.

If that sounds nearly impossible to you, then you're not alone. Engineers from ACE Controls Inc. had their doubts, too, when they were assigned to carry out the task three years ago. "It was like trying to put ten pounds of sausage in a five-pound bag," notes Dave Claydon, senior project engineer for ACE. "We were stumped."

Nevertheless, ACE recently rolled out the Magnum, an industrial shock absorber that met those initial goals, and then some. The shock absorber, used to decelerate loads in robotics, on assembly lines, conveyors, and servo systems, features some rather shocking performance specs. It offers up to 3.9 times the effective weight capacity and absorbs 50% more impact energy than its predecessors, without an increase in size or cost. Equally significant: It includes a fully threaded body, which provides users with greater flexibility in mounting the shock absorber.

Spongeless accumulator. All of that would be a tall order for any engineering department, even if the company hadn't been seeking a 50% performance improvement. The reason: A fully threaded body takes up important real estate on the outer diameter of the shock absorber's body. And the energy-carrying capacity of the product is dependent upon its usable piston area, which diminishes when the body shrinks.

So how did engineers do it? The key, they say, was a combination of software analysis and old-fashioned brainstorming. For more than a year, ACE Controls' engineers mulled over Magnum's stickiest problem: The combination of a fully threaded body and larger piston area left no room for a so-called "sponge"—a closed-cell foam inside the cylinder that soaks up hydraulic oil when the piston rod moves back and forth.

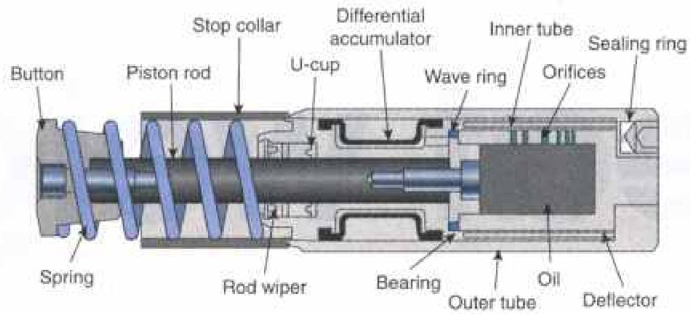
Over the years, sponges have been a common solution in shock absorbers. Because they are loaded with voids, they act as mini-accumulators—providing a place for hydraulic oil to reside in the shock after the oil has been displaced by the piston. During operation, the piston rod

Magnum industrial shock absorbers: better performance, same size.

retracts, and the oil is forced out of the cylinder's inner tube and into the sponge.

With less room for a sponge, however, ACE Controls engineers faced a maddeningly complex dilemma: Where would they put the displaced oil? At first, they considered smaller sponges. On the surface, smaller sponges seemed a viable solution. However small they might be, they at least gave displaced oil a place to accumulate.

MC series, self-compensating



Instead of a sponge, a nitrile bladder (located between the spring and inner tube) serves as an internal accumulator.

But in lab tests, fatigue became a problem—for the sponges and other associated parts. "We were trying to put so much oil into the sponges that everything—the rods, sponges, tubes, buttons, all of it—was failing," Claydon says. "It seemed like nothing could survive the tests in the lab."

After more than a year of failed tests, engineering staff members decided to wipe the slate clean and gather for a brainstorming session. "Someone said, 'Describe the perfect accumulator,'" recalls Mike Ferkany, engineering manager for ACE Controls. "And we decided that the perfect accumulator would be one that was barely there—all air and very thin walls." From that discussion emerged the idea for a thin-walled nitrile bladder. The bladder, they concluded, would be placed inside the shock absorber, in a void created in the front bearing.

In a sense, the bladder would act much like a traditional air-over-oil accumulator. It would fill with oil and then use its own air pressure to force the oil back out when the shock's rod extended. There were, however, two key differences between it and traditional accumulators: The bladder would reside inside the shock absorber, rather than outside. Also, the thin-walled bladder would dramatically expand and retract like a balloon as oil flowed in and out.

Software solution. The new concept, however, presented engineers with another dilemma: how to analyze the stresses on the bladder, as well as the performance of the system in general.

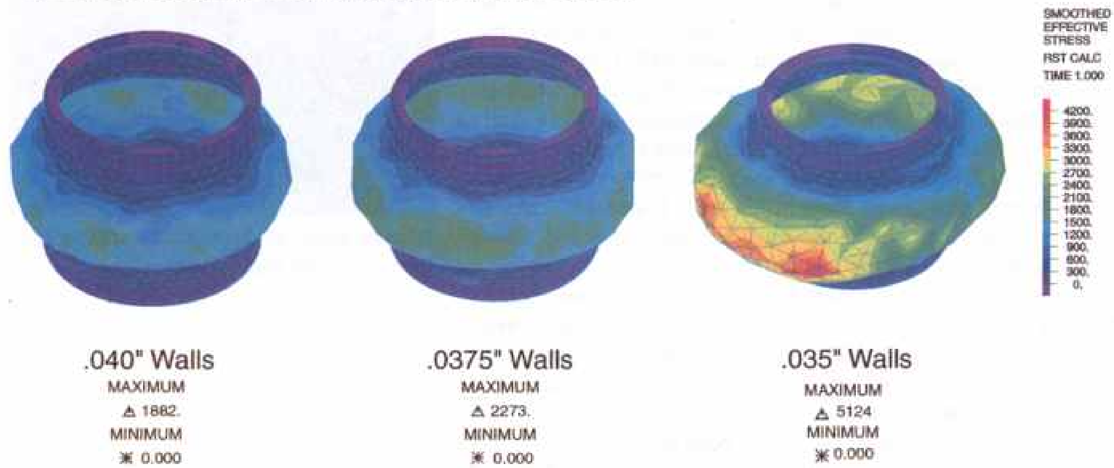
Engineers knew, of course, that they could build, fail, and re-build countless prototypes. But they also knew that they had already chewed up the previous 17 months doing precisely that. So they took a different tack: software analysis. "I knew that software would answer the critical questions without the need for loads of prototypes," Ferkany says.

Indeed, software could help answer those questions, they learned. But first they needed to find a software program that could accurately analyze the situation. Problem was, this was no ordinary finite element analysis. Variables included the load, its velocity, the flow of fluid through orifices in the inner tube, the pressure of that fluid, and the effect of the pressurized fluid on the bladder walls. "We needed finite element analysis—but not just mechanical FEA," Ferkany says. "So we searched the world over to find a program that could combine FEA with computational fluid dynamics and give us a complete system analysis."

To locate the best program, Ferkany contacted 11 different FEA software manufacturers and gave them each a test: If 800 pounds-force hit the shock absorber at four feet per second, what would the deceleration be? From empirical data, Ferkany already knew the answer. What surprised him, though, was that most existing FEA manufacturers couldn't—or didn't want to—solve it.

One did, however. Adina R&D Inc. (Watertown, MA) replied with an answer approximately two-and-a-half months after Ferkany's initial query. "They gave me back the exact curve that we had already gotten from our lab," Ferkany recalls. "So I

Comparison of the Effects of Equal Pressure on Different Bladder Wall Thicknesses (PSI of Stress)



Analytical software techniques were key to determining bladder performance. Simulations show how pressure affects the bladder when wall thickness is reduced from 40 thousandths to 35 thousandths of an inch.

told them we wanted their software."

The key to the success of the Adina software was its ability to analyze the fluid-structure interaction, engineers say. "Most programs either do fluid flow or structural analysis," notes Jan Walczak, principal lead for Adina R&D. "But they can't solve fluid-structure problems that are coupled."

Using Adina's software, ACE Controls engineers were able to analyze the stresses on the bladder as oil flowed in and out. More important, they were able to determine how thousands, or even millions, of cycles would affect the bladder nitrile material and surrounding parts.

User's choice. With the software program in place, ACE Controls engineers not only altered the product—they changed the corporate culture, as well. "This was completely different from anything we'd done before," Claydon says. "Sponges had been easy to use. We never had to worry about elaborate stress calculations. But this was a case where we couldn't use the old way anymore."

ACE engineers finished the design of the bladder and introduced the Magnum shock absorber in mid-1999. The new product is essentially used by the same customer base, but it provides those customers with greater effectiveness and flexibility. Effective weight ratings of the new shock absorber line increased dramatically for all bore diameters. A 1.375-inch Magnum, for example, decelerates an effective weight of 110,000 lbs, compared to 28,000 lbs for identically sized conventional models. Other bore sizes offer similar gains.

At the same time, the Magnum Group also provided ACE Controls' customers with a product that's no bigger than its predecessor and costs no more. "Now our users have a choice," Ferkany says. "They can build more safety factors into their designs with the same size shock absorber. Or they can go to a smaller size and save money." dn

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